CHAPTER I

INTRODUCTION

1.1 Background

Propylene glycol is one of the chemicals that are used as industrial raw materials, particularly industries that use polyester compound and as de-icing solution. Propylene glycol is used by chemical, food, and pharmaceutical industries. The food and Drug Administration (FDA) has classified Propylene glycol as an additive that is "generally recognized as safe" for use in food and as additives in paint industry (Kirk and Othmer, 1992).

In Indonesia, Propylene glycol plant is one of the industries that provide good opportunities for the country. Indonesia has not been able to meet the needs of Propylene glycol, so that Indonesia still imports from other countries. Because of the inability of producers, to meet all the demand Indonesia depend on imports from other countries. If the Propylene glycol plant is built, the benefits are:

a. Create jobs for the people in Indonesia.
b. Adding foreign exchange.
c. Propylene glycol needs can be met without imports from other countries.
d. Encouraging the development of the Plant that use Propylene glycol as raw materials.
e. It is expected to penetrate the export market.

1.2 Capacity of The Plant

In deciding the capacity of the Plant Design, it must consider some factors, such as:

a. Market in Indonesia

Indonesia is a country that has not been able to meet all the needs of Propylene glycol, so that Indonesia imports it from overseas. It can be seen from the increase in data import of the year 2011 to 2015, as shown in the Table 1.1.

Table 1.1. Import of propylene glycol in Indonesia from 2011 to 2015

Years	Propylene glycol import (kg)
2011	2564245
2012	3081940
2013	3038056
2014	2978595
2015	2934817

(BPS, 2015)

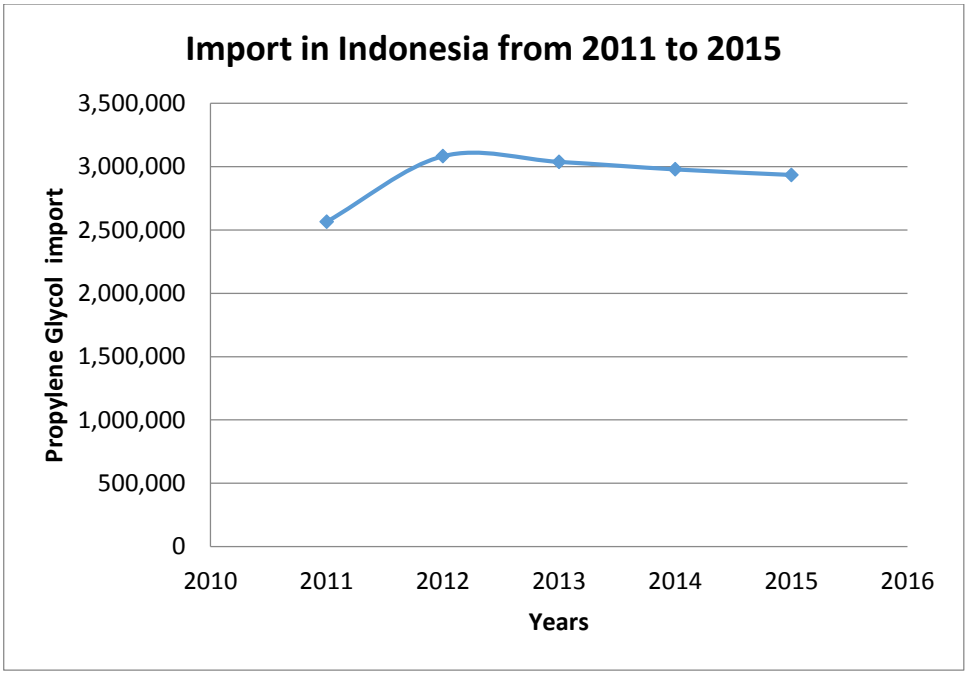


Figure 1.1 Need of Propylene glycol in Indonesia

The increase in the imports of propylene glycol are consistent with the equation of a straight line:

y = 63780x - 1E+08

From this equation, it can be estimated that propylene glycol import in 2020 will be equal to 28,835.6 Tonnes/year. Based on that estimated need for propylene glycol above, the plant capacity is then determined to reach 50,000 tonnes/year.

Table 1.2 Data of propylene glycol production capacity abroad

No.	Producer	Location	Annual capacity, 10^3 ton
1	ARCO Chemical Company	Bayport, Texas USA	163
2	Dow Chemical USA	Freeport, Texas USA	113
3	Dow Chemical USA	Plaquemine, Los Angeles	68
4	Eastmen Chemical Company	S. Charleston, West Virginia, USA	36
5	Olin Corporation	Brandenburg, Kentucky, USA	32
6	Texaco Chemical Company	Beamon, Texas, USA	68

b. The Existing Capacity of propylene glycol Plant

In determining the capacity of the Plant, the writer must know the data capacity of the existing Plant. The data capacity of the existing Plant can be seen in Table 1.2.

Based on the data, it can determine the capacity of propylene glycol Plant. The capacity is 50,000 tons / year. The reasons are:

1. Provide benefits.
2. It can meet domestic needs and the rest can be exported to increase foreign exchange.
3. It is expected to meet its domestic needs

c. Determining The Location of The Plant

Site selection is important in determining the value of the production and economic, the Plant will be established in the district Gresik West Java, with consideration of primary and secondary factors.

1. Primary Factors

a. The availability of The Raw Materials

The plant of propylene glycol should be built near the sources of raw material. The main raw materials include Propylene oxide from Zhangdian Petrochem China, Sulphuric acid from PT. Petrokimia Gresik, Sodium Hydroxide from PT.Perdana Mulia Jaya Surabaya, Methanol from PT. Kaltim Methanol Industry Kalimantan and Water from Brantas and Bengawan Solo River

b. Transportation

In the supply of raw materials and marketing product, it is necessary facilities and adequate transportation infrastructure. To supply the raw materials, it can be carried out using sea transportation is used through Tanjung Perak port. As for product marketing will be sell in around Surabaya, which has a complete transportation in land, sea and air it is very supportive for marketing.

c. The Workers

Selection workers should have the certain considerations such as quality, number, productivity, minimum salary, and workers skills. Labour selected from the gresik areas. According to the gresik regency government, percentage contribution is 49.52% in industry sector. (Government of gresik, 2015).

d. The Utilities Supply

Utilities that need to be considered are water, electricity, and other supporting facilities.

e. Marketing

Marketing of products is made in East Java is an industrial area, both small and large industrial industry which is a potential market in the production of propylene glycol, such as the cosmetics industry, the pharmaceutical industry and food industries.

f. The Condition of Location

Gresik is located in west side of Surabaya which provides industrial land its lots to local, national and foreign investor, A large number of industries have established in Gresik. Gresik does not stop the effort in boosting the economical revenue by diversity the existing industry. At this moment development industry can be a positive influence for society in gresik.

2. Secondary Factors

a. The Land Expansion

Gresik is an industrial area. It needs to expand the land for Plant expansion in the future.

b. The Government Policies

The establishment of the Propylene glycol Plant will be supported the government policy to develop industry in Java. The establishment of the Plant should pay attention to the environmental safety and it does not interfere with the surrounding area.

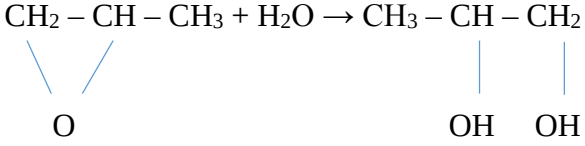
1.3 LITERATURE REVIEW

1.3.1 The Kind of Process

Propylene glycol can be produced by the hydrolysis of propylene oxide with excess water and can also by adding methanol as a diluent for propylene oxide that not soluble in water.

Production of propylene glycol can be done by 2 processes, among others:

a. Hydration of propylene oxide without a catalyst



(1.2)

The conversion of propylene oxide hydration process without catalyst reaches 90%. This process takes place at temperatures of 120-190°C at a pressure of 2,170 kPa (Kirk and Othmer, 1992).

b. Hydration of propylene oxide with a catalyst

Reaction:

$$CH_2 - CH - CH_3 + H_2O \xrightarrow{H^+} CH_3 - CH - CH_2 \quad (1.3)$$

(O; OH OH)

At Chan and Seider study in 2004 using ratio of propylene oxide ratio: water: methanol: sulphuric acid as a catalyst is 43.04: 802.8: 71.87: 20 lbmol. The process operating conditions use temperature of 77-93°F with a pressure of 1 atm, obtained a conversion of 99% (Chan and Seider, 2004).

Looking at the process conditions and the resulting conversion on every production process propylene glycol above, the selected process is the hydration of propylene oxide with an acid catalyst.

1.4 The Usefulness of Products

Propylene Glycol with another name 1,2-propanediol is one of the chemicals widely used in various industries both as raw materials and auxiliary materials. Usage is very broad in various industries such as food preservative in the food industry, as softener and moisturizer in the cosmetics industry, as one of the formulas in the pharmaceutical industry, and as additives in paint products industry (Kirk and Othmer, 1992).

It can be used as an emulsifier to stabilize mixtures of two or more immiscible liquids. This often occurs in the preparation of cosmetics, where oil and water must be mixed to produce creams or lotions, and in the preparation and processing of some foods. It is a useful excipient, a pharmacologically inactive substance that acts as a carrier for the active ingredients in medication. It can be used for boiling point elevation or

freezing point reduction, which makes it an effective de-ice and antifreeze solution.

1.5 Properties of Physical and Chemical Raw Materials and Products

A. The Primary Raw Materials

1. Propylene Oxide (Kirk and Othmer, 1992).

a. Physical properties :

Molecular weight	: 58.10 g/gmol
Density	: 0.82 g/cc
Purity	: 99.95%
Melting point	: -111.93°C
Boiling point at 1 atm	: 34.27778°C
Viscosity in 10°C	: 0.36 cp

b. Chemical properties :

- Reaction with water

  Propylene oxide reacts with water, either with an acid catalyst or a base catalyst even without a catalyst
- reaction with ammonia

  If it reacts with ammonia to form mono-, di-, tri-iso propanalamine. Reacts with primary amines to form secondary and tertiary amines.
- reaction with organic acids

  If it reacts with organic acids to form glycol mono-ethers
- reaction with natural products

  If it reacts with the hydroxyl groups in the sugar cellulose and glycol with an alkaline catalyst, it forms hydroxyl propyl ether and ether and glycol derivatives.

2. Water

a. Physical properties :

Molecular weight	: 18.01 g/gmol
Melting point at 1 atm	: 0°C

Boiling point at 1 atm	: 100°C
Critical pressure	: 218 atm
Critical temperature	: 374.20°C
Heat of fusion	: 1.43 kkal/gmol
Heat of vaporization	: -68.31 kkal/gmol
Refractive index	: 1.33
Density at 25°C	: 1.02 g/cc
Viscosity	: 0.69 cp

b. Chemical Properties :

- Easy dissolving liquid, solid or gas
- As a hydrolyses reagent in the hydrolysis process

3. Sulphuric Acid (Perry, 1999)

a. Physical properties :

Molecular weight	: 98.08 g/mol
Purity	: 98%
Phase	: Liquid
Boiling point at 1 atm	: 340°C
Melting point	: 10.49°C
Density	: 1.84 g/ml

b. Chemical Properties :

- If reacted with HNO_3 will produce nitrite ions / nitronium (NO_2^+) are useful in the nitration reaction
- $HONO_2 + 2H_2SO4 \rightarrow 2H_2SO_4^- + NO_2^+ + H_3O^+$ (1.5)
- H_2SO_4 in the nitration reaction has the function of preventing HNO_3 to form hydrogen ions (H^+) and nitrate (NO_3^-) and form the nitronium ion (NO_2^+)

- H_2SO_4 has a pull force of the water and generates a large hydrate compounds such as $H_2SO_4.H_2O$ and $H_2SO_4.2H_2O$ (Fessenden, 1992).

4. Sodium Hydroxide

   a. Physical Properties (Kirk and Othmer, 1992):

Molecular weight	: 39.99 g/mol
Purity	: 50%
Phase	: Liquid
Boiling point at 1 atm	: 1.388°C
Melting point	: 318°C
Density at 20°C	: 2.13 g/ml
Latent heat	: 167.40 kj/mol

   b. Chemical Properties (Fessenden, 1992):

   In this process NaOH as neutralizer of nitric acid

   Reaction:

$$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O \quad (1.6)$$

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O \quad (1.7)$$

5. Methanol

a. Physical Properties :

Molecular weight	: 32.04 g/mole
Purity	: 99.98%
Phase	: Liquid
Colour	: Colourless
Boiling point at 1 atm	: 64.75°C
Melting point	: -97°C
Density at 30°C	: 782.81 kg/m^3
Viscosity at 30°C	: 0.51 CP
Critical temperature	: 239.43°C

Critical pressure	: 79.81 ATM
Purity	: > 85% w of methanol
Impurity	: < 15% w of water

b. Chemical Properties :
   - The reaction with methanol occur by breaking the C-O group and -H bond.

B. Main Products

1. Propylene Glycol (Kirk and Othmer, 1992)

a. Physical Properties :

Molecular weight	: 76.09 g/gmol
Purity	: 99.50%
Melting point at 1 ATM	: -60°C
Boiling point at 1 ATM	: 187.40°C
Heat of vaporization	: 12.94 kkal/gmol
Refractive index	: 1.43
Density at 25°C	: 1.03 g/cc
Viscosity	: 0.58 cp
Specific heat	: 0.59 kal/g°C

b. Chemical Properties :
   - propylene glycol is used as an initiator in the base catalyst to produce mono (primary and secondary) and Dieter (polyether polyols)
   - propylene glycol condensation with the aldehyde produce a cyclic acetyl or 4 methyl 1.3 dioksilan
   - Propylene glycol esterified with maleik, fumarik or similar results acids like halide or anhydride acid produces mono and di-esters with peroxide catalyst at low pressure with adhesive.